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ABSTRACT

It is suggested that models of human problem solving are useful in the analysis of word fluency (WF) test performance. In problem-solving terms, WF tasks would require the subject to define and clarify the conditions of the task (task acquisition), select and employ appropriate strategies, and monitor one's performance. In modern neuropsychology, the frontal lobes have been attributed a crucial role in general problem solving. A simple information-processing model is applied to preliminary experimental and clinical data on qualitative features in neurological patients' WF performance. The study in question was performed at the Boston Veterans Administration Hospital. The WF results are part of a project which focused on the problem-solving skills of chronic alcoholics. It is proposed that the model reveals a hierarchy in the susceptibility of the problem-solving components (task acquisition, strategy selection, and monitoring) to neural damage. Figures and tables illustrate the text. (MSE)

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WORD FLUENCY: A TASK ANALYSIS

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1. INTRODUCTION

"I shall say a letter of the alphabet, then I want you to give me as many words that begin with that letter as you can and as quickly as you can. For instance, if I say 'B', you might give me 'bag, battle, bed, and so on'. Do not use words which begin with a capital letter like the names of brands, people, or places such as 'Bob or Boston'. Also, do not give numbers, or begin the same word but with a different ending, for example, 'eat, eating'. Do you have any questions? Begin when I say the letter. The first letter is S."

These instructions cited from Borkowski et al. (1967) describe a typical word fluency (WF) task. Specifically, the test is a phonetic fluency task, going by a name of letter. Another type of fluency measure which the subjects usually find easier, are tests of semantic WF, where one has to name animals, fruits, vehicles and so on within a short period of time (for a description of various WF tests in clinical use, see Lezak 1983).

Originating from intelligence research, WF measures have been used quite widely in neuropsychology. The main reason is that they have been repeatedly shown to be sensitive to frontal lobe damage, particularly to left anterior lesions (Benton 1968, Borkowski et al. 1967, Milner 1964, Perret 1974, Ramier & Hecaen 1970). It is unclear, however, why WF tests discriminate between frontally lesioned and other brain damaged patient groups. Rather vaguely, the defect has been labeled as a "higher-level verbal deficit" or related to the subject's ability to organize his thinking. The single exception is Perret (1974), who suggests that phonetic WF tasks measure ability to suppress the habit of using words according to their meaning. Particularly left frontal damage was related to impairment of this inhibitory mechanism.

In the present paper it will be suggested that models of human problem-solving are useful in the analysis of WF test performance. In problem solving terms, WF tasks would require the subject to define and clarify the conditions of the task (task acquisition), select and employ appropriate strategies, and monitor one's

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performance (Fig. 1). It is obvious that a WF task is not a problem in the same sense as tests like the Wisconsin Card Sorting. Still, it can be considered as a "problem" because it represents a new task situation, and the ways of solving it effectively are not always immediately available to the subject. In modern neuropsychology, the frontal lobes have been attributed a crucial role in general problem solving (e.g., Luria 1980, Damasio 1979).

The rest of the paper will focus on preliminary experimental and clinical data of qualitative features in neurological patients' WF performance. It will be suggested that these results could be fitted into the simple information-processing model in Fig. 1, and that one may observe a kind of hierarchy in the susceptibility of these components to neural damage.

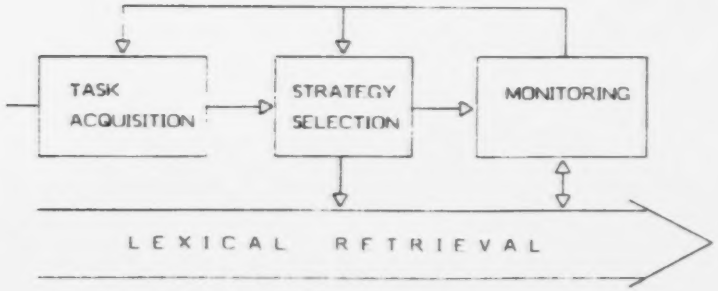

Figure 1. Hypothetical model of word fluency performance.

2. WORD FLUENCY PERFORMANCE IN KORSAKOFF PATIENTS: FAILED MONITORING

This study was performed at the Boston Veterans Administration Hospital under the supervision of Professor Nelson Butters, Ph.D. The WF results are part of a project which focused on the problem-solving skills of chronic alcoholics and Korsakoff patients (Laine 1984, Laine & Butters 1982). (Initial analysis of the data was performed in collaboration with Dr. Elisabeth Moes, Ph.D.)

In one session, several WF tasks were administered to groups of alcoholic Korsakoff patients, chronic alcoholics, and normal controls. Altogether 24 subjects were tested, 6 Korsakoffs, 8 alcoholics and 9 controls. The groups did not differ significantly in age, education or WAIS Vocabulary score (Table 1). We used three phonetic tasks (F,A,S) and four semantic tasks, where the subjects had to list orally as many animals, fruits, vehicles and weapons as they could within one minute. The order of the tasks was fixed starting with the phonetic tests (see Fig. 2). The instructions were similar to those used by Borkowski et al. (1967).

Table 1. Mean age, years of education and WAIS Vocabulary scores of alcoholics, controls and Korsakoff patients.

	Alcoholics (n=8)	Controls (n=9)	Korsakoffs (n=6)
Age, years	56.8 (3.0)	55.6 (2.5)	57.5 (4.8)
Education, years	12.8 (1.8)	11.8 (2.9)	12.5 (2.0)
WAIS Vocabulary scaled score	11.9 (1.9)	12.2 (1.1)	11.8 (3.4)

Standard deviations are shown in parentheses.

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The ordinary quantitative results, the number of words produced in one minute, are presented in Fig. 2. One-way analyses of variance failed to reach statistically significant differences between the groups except for the category of fruits. Furthermore, the number of repetition errors or perseverations for each subject was counted. Repetition error is simply an occasion when the subject produces exactly the same word again, e.g., cat-dog-horse-cat. In the total number of perseverations (Fig. 3) the groups differed significantly, and this is solely because of the accumulation of perseverations in the Korsakoff group. The most interesting finding is, that the distribution of perseverations across the tasks (Fig. 4) is highly skewed: in the Korsakoff group, perseverations accumulate to the first task of a test type.

The tentative explanation for the failed monitoring at these points is that here the impaired Korsakoff patient is facing a new task and the limited resources of attentional control available are needed to both task acquisition and strategy selection. One might argue that the severe anterograde amnesia of these patients would explain the high number of perseverations, and short-term memory is certainly involved when the patient attempts to keep track of which words have already been said. Being a purely amnesia-related phenomenon, however, one would expect to find a flat distribution of perseverations. Moreover, a single case of relatively "pure" acute transient global amnesia, which the present author has tested with WF tasks during the attack, did not exhibit perseverative tendencies, although being severely amnesic. Fitted into the model (Fig. 1), the accumulation of perseverations to certain parts of a WF test battery would indicate a Component 3 defect in Korsakoffs. It is notable that various problem-solving deficits have been reported previously in these patients (for review, see Butters 1985). Of course, there still remains a possibility of some kind of an interaction effect between poor memory and defective monitoring, and this question awaits further studies.

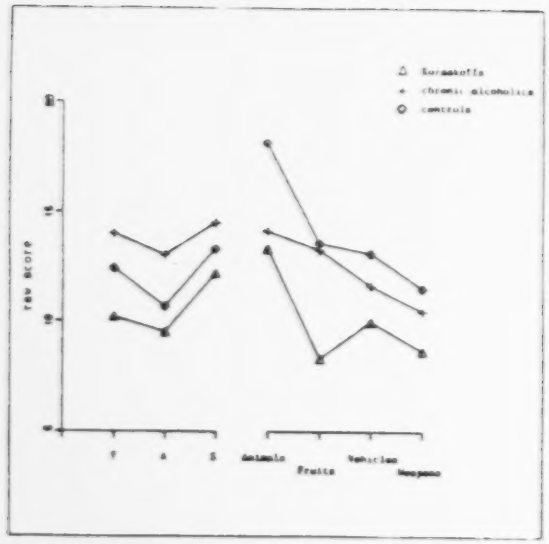

Figure 2. Group means on word fluency tasks.

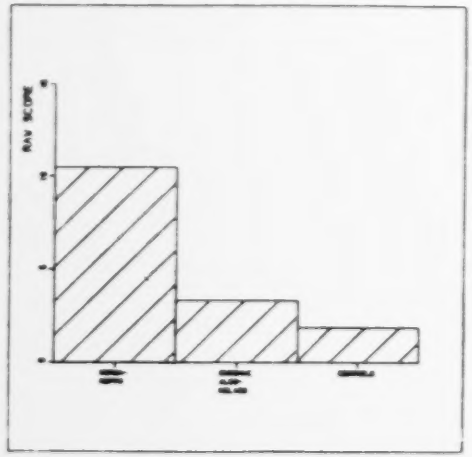

Figure 3. Group means of total perseverations across the word fluency tasks. $F(2,20) = 7.76$; $p<0.01$.

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3. DEFICIENT TASK ACQUISITION

Clinical manifestations of the hypothetical Component 1 defect, problems with task acquisition, represent a much more severe disorder often accompanied by even otherwise inadequate WF performance. The data to be presented is based on single cases suffering from a relatively severe "frontal lobe syndrome" defined by neuropsychological assessment. Etiology is variable. Instructions of the phonetic fluency task were somewhat different from the ones used with the Korsakoff patients: only names of people had to be excluded, not names of brands or places.[1]

The first case, patient I.V., is a 71-year-old right-handed female patient suffering from a haemorrhage in the area of the left caudate nucleus. A template of the lesion is presented in Fig. 5. Neuropsychological examination revealed typical frontal lobe damage signs such as planning defects, tendency to perseverate, as well as impulsivity and disinhibition. Moreover, she suffered from amnesia and was also anomic. The results of two WF tasks, naming by letter S and animal listing, are presented in Tables 2 and 3 (see Appendix). On the first task, she shifts to another letter, thus violating the task rules. Also, the sheer number of words produced is quite low. There is one perseverative error. On animal naming, she starts by listing only animals starting with letter K, which exemplifies her difficulties in set shifting. Then she gets stuck on a nonrecognizable word which she does not recognize even by herself! After that, she is being reminded of the task instructions (marked by "!"), and she continues with a couple of animal names starting again with letter K. Towards the end of the task, the interfering effect of the previous phonetic test is once again evident when she starts to produce first names. The final products appear to be totally unrelated words, the last one being a derivation.

The second case, patient S.V., is a 60-year-old right-handed female patient suffering from normal pressure hydrocephalus. The main CT findings were enlarged ventricles as well as decreased density in the frontal and parietal white matter. On neuropsychological testing, a clear frontal lobe symptom complex was observed: she was euphoric, concrete, exhibited some loss of inhibition, and had quite a severe

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1 All of these cases have been examined at the Turku University Central Hospital. Detailed neurological and neuropsychological data of these cases are available from the author upon request.

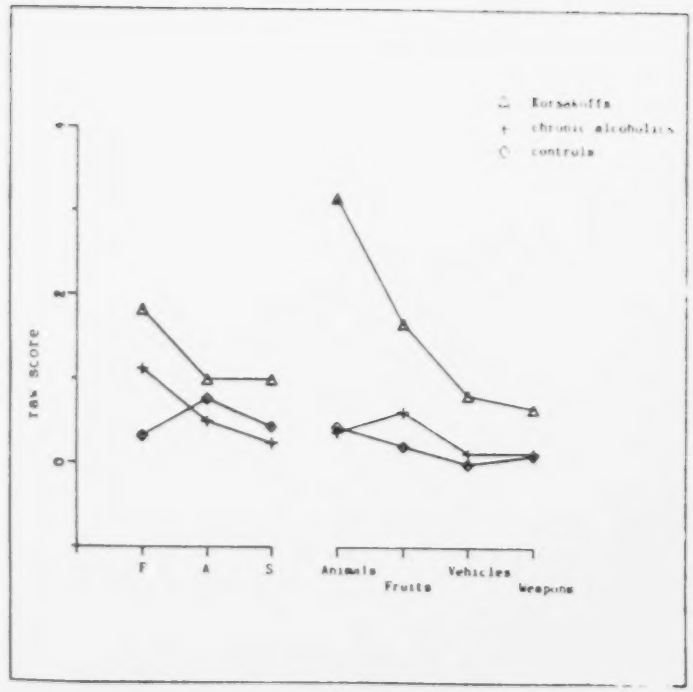

Figure 4. Group means of perseverations on word fluency tasks.

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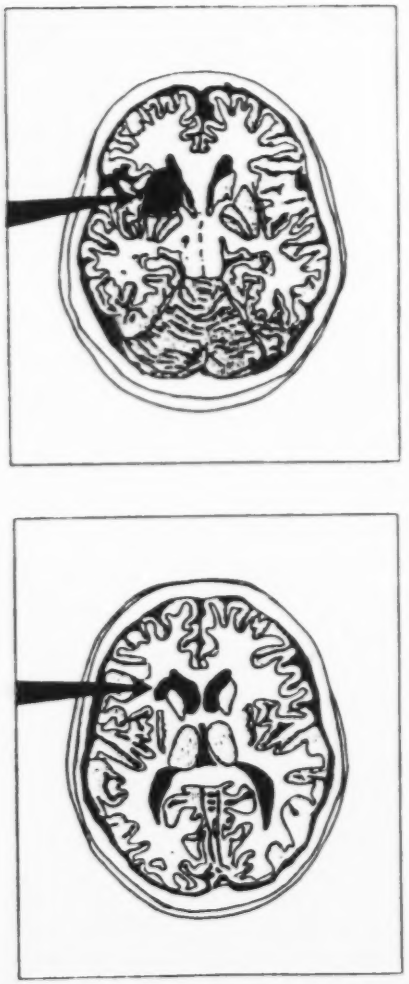

Figure 5. CT scan templates of patient I.V.: Haemorrhage of the left caudate nucleus.

memory disorder. On the phonetic fluency task (Table 4, Appendix), she starts with first names, which she was just instructed not to do. She is reminded of this fact, but there still appears one first name. The next error is a derivation of the word "sugar", followed by a rather uncommon choice: Seven Brothers, being one of the classic works in Finnish literature.

The third case, patient A.E., is different in the way that so called "frontal damage signs" were not so prominent in his neuropsychological status. He is 67-year-old, right-handed, and clinically diagnosed as suffering from senile dementia. His neuropsychological defects were quite extensive, and he had a clear language disturbance with features of fluent aphasia. This kind of a language pathology is typical in Alzheimer's disease (Obler & Albert 1981). On the animal naming (Table 5, Appendix), the patient subsequently produces some paraphasic errors. More interestingly, after the start he soon continues along the lines of the first task abandoning the most recent instructions. At the end, there is one perseverative error.

The WF test protocols of these severely impaired neurological patients show several examples of inadequate task acquisition, i.e., Component 1 defect. A significant part of the errors appear to be related to interfering effects of the previous task. It is notable, that the shifting of a test type (phonetic-semantic) also produced the highest number of perseverations in the Korsakoffs (Fig. 4).

4. FITTING WORD FLUENCY PERFORMANCE INTO A MODEL

Two types of disordered WF performance have been delineated on the basis of the empirical data:

(a) Component 3 defect: perseverative errors

(b) Component 1 defect: breaking the task rules, perseverative errors, poor quantitative performance

The milder, the monitoring defect, can occur in isolation, but the more severe Component 1 defect is accompanied by deficits in monitoring and impaired quantitative performance. The reason for monitoring to impair first can only be speculated upon: monitoring is peripheral to the actual lexical search, and it depends in part on short-term memory. One significant factor in elucidating these pathological phenomena appears to be set shifting. In a way, these shifting or

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interference effects can be related to Perret's (1974) notion of suppression of normal (earlier) ways of acting. However, Perret focuses on a single WF test type, and in the present study interference effects are not related to this factor. Rather, other task-related variables such as the order of the tests and the specific instructions seem to affect the form of the set shifting errors.

Although not specifically studied in the present experiments, it is tempting to relate this crude hierarchy of WF pathology to defects in more complex problem-solving tasks. Laine (1984) attempted to describe chronic alcoholics' and Korsakoff patients' defects on 20 Questions Game tasks with a similar model that is applied here. On these difficult tasks, chronic alcoholics had their main difficulties in initially selecting appropriate strategies. The Korsakoffs, on the other hand, used poor strategies throughout the tasks and their performance was not facilitated by the examiner's feedback. This could be considered as a defect in monitoring one's performance. On the basis of preliminary data, it is difficult to conclude whether this monitoring defect is in fact related to Korsakoff patients' perseverations on WF tasks. It can only be noted, that the two Korsakoffs who produced most WF perseverations, were also the most impaired on the 20 Questions Game tasks.

In the present article, the main emphasis has been on error analysis, and Component 2, strategy selection, has not been studied. Potentially, this would give valuable information: Estes (1974) comments that successful performance on these tests depends in part on the subject's ability to "organize his output in terms of clusters of meaningfully related words". Lezak (1983) gives examples of effective clustering strategies of WF tasks. Even though the use of clustering certainly varies from one subject to another, there is one strategic aspect, in which various neurological patients seem to act in a relatively similar fashion. That aspect is the use of "prototypical" names (cf. Rosch 1975) in initiating a semantic WF task. In Fig. 6, the most common first four words in animal naming used by 50 unselected neurological patients are presented. Only three words, "dog-cat-cow", account for nearly half of the total number of counts. It must be emphasized that in this particular WF test no examples of suitable animal names or subcategories were given, and the patient was simply instructed to name as many animals as possible within one minute. As there appears to be unity of performance in this respect, various semantic WF tasks should be useful in prototype research with normal populations.

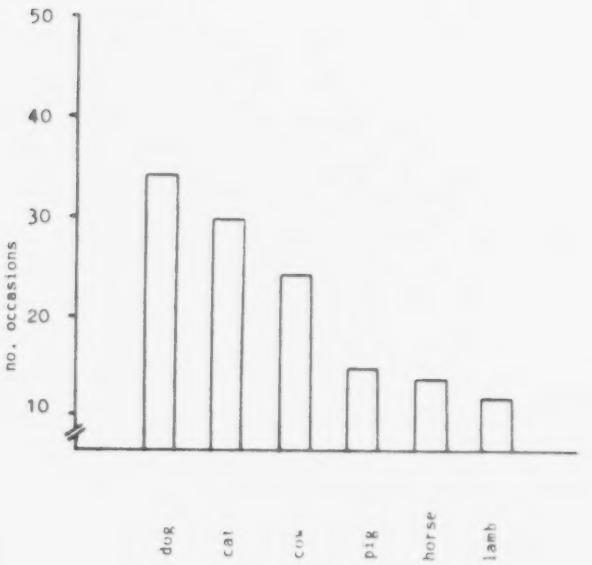

Figure 6. Animal naming: the most common first four words (n = 50).

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Appendix, Tables 2-5. Word Fluency Protocols of Patients.

TABLE 2.

PT. I.V.: WORD FLUENCY BY LETTER S

0 - 15"	SENTTI	CENTIMETRE
	SYSMÄ	(A PLACE NAME)
	SYYHELMÄ	ITCH
15 - 30"	SENTTI	(PERSEVERATIVE ERROR)
	SIELU	SOUL
	SOLU	CELL
	SOPPA	SOUP
30 - 45"	SULHO	BRIDEGROOM
	HOME	MOULD
	HOUKUTUS	TEMPTATION
45 - 60"	-	

Errors underlined.

TABLE 3.

PT. I.V.: ANIMAL NAMING

0 - 15"	KARHU	BEAR
	KETTU	FOX
	KURKI	CRANE
	KUUSYY, EI SE OO	(NONWORD), I GUESS IT DOES
	VISSIIN MITÄÄN	NOT MEAN ANYTHING
15 - 30"	(!) ELÄIMIÄ JUU	OH YES, ANIMALS
30 - 45"	KIURU	LARK
	KOTKA	EAGLE
	KALLE	(FIRST NAME)
	PEKKA	(FIRST NAME)
	PELLE	(FIRST NAME)
45 - 60"	PUU	(TREE)
	HEITTO	THROW (noun)
	HEITTONARU	LASSO

Errors underlined.

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TABLE 4.

PT. S.V.: WORD FLUENCY BY LETTER S

0 - 15"	SANNI	(FIRST NAME)
	SUOMA	(FIRST NAME)
	(!)	
	SIRKKA, NE ON	(FIRST NAME),
	KAIKKI IHMISTEN	THEY ARE ALL
	NIMII	PEOPLES' NAMES
15 - 30"	SOKERI	SUGAR
	SIIRAPPI	SYRUP
30 - 45"	FARIINISOKERI	BROWN SUGAR
	SEITSEMÄN VEL-	SEVEN BROTHERS
	JESTÄ	
45 - 60"	SIKA	PIG
	SORSA	WILD DUCK

Errors underlined.

TABLE 5.

PT. A.E.: ANIMAL NAMING

0 - 15"	KOIRA	DOG
	KANA	HEN
	HEVONEN	HORSE
	SIILI	HEDGEHOG
	SIMPPU	COTTUS, A FISH
	SIIRIÄINEN	(SURNAME)
	SAMMAL	MOSS
	SUKSET	SKIS
	SAUVAT	SKI-STICKS
	SAJAT	(NONWORD)
15 - 30"	SURVIAINEN	MOSQUITO
	SAKSANMAA	GERMANY
	SIPPO	(FIRST NAME)
30 - 45"	SAMPO	(FIRST NAME)
	SYLKYLÄINEN	(NONWORD)
45 - 60"	SORSA	WILD DUCK
	SAUKKO	OTTER
	SIILI	(PERSEVERATIVE ERROR)

Errors underlined.

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